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E. Etim and M. Greco : p-p ELASTIC SCATTERING AT LARGE MOMENTUM TRANSFERS. -

(Nota interna : n. 377)

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The considerable amount of accurate data now available on p-p elastic scattering at large momentum transfers and their many interpretations seem to ring quite definitely the death knell of the statistical theory of strong interactions. The lack of the so-called Erickson fluctuations in the angular distribution at fixed energy and in the energy spectrum at fixed centre of mass angle and the fact that the once celebrated Orear fit obtained theoretically by Hagedorn reproduces only the gross features of large angle p-p scattering (v. Fig. 1) suggest the statistical model be ruled out both as a compound nucleus model and as a phase space theory.

What is now left?

The search for an empirical formula which can best represent all the available data has led to the conclusion that $S \sin\theta = 4(p^2+m^2)\sin\theta$ is the more suitable kinematical variable and not the transverse momentum $p_\perp = p\sin\theta$ chosen previously by Orear and also by Hagedorn. When $\log_{10}(d\sigma/dt)_{cm}$ is plotted against $S \sin\theta$ two straight lines with different slopes "seem" to result (v. Fig. 2) and the point of intersection of these straight lines ($p^2_{cm} \sim 3.4$ (GeV/c)^2 is the mysterious break-point (kink) which quite recently appears to be getting more than a fair share of the attention of experimentalists and theorists alike.

The many theories evolved around this kink include. -

i) - the onion-shape theory of the nucleon structure proposed by Akerlof and colleagues. According to this theory the proton consists of different sheets surrounding a central core; this latter is mostly responsible for the large angle scattering. Akerlof and his group succeded in fitting all data with three straight lines with slopes corresponding to three sheet radii of 0.90, 0.52, 0.34 fermis respectively. (v. Fig. 3).

ii) - the threshold theory of Allably and collaborators which sees in the kink the onset of baryon and anti-baryon production.

Interesting though these various conjectures they are not exempt from serious objections. For instance in the collision of two protons, which of these particles must be considered as a probe particle which gives detailed information through scattering on the onion-structure of the other and what is the physical meaning of the sheet radii?

In our opinion, it is the dependence on the variable S sinθ and not the appearance of a kink which should claim more attention. In view of the fact that the transverse momentum has been discarded as a suitable kinematical variable we have plotted the Orear formula for

$$\left(\frac{d\sigma}{dt}\right)_{cm} = \frac{\pi}{p_{cm}^2}\left(\frac{d\sigma}{d\Omega}\right)_{cm} = \frac{\pi}{p_{cm}^2} \cdot \frac{A}{s} \exp\left(-p \sin\theta / b\right)$$

against S sinθ taking for simplicity $\theta \sim 90^o$. A = 600 $(GeV)^2$ mb/str., b = 0.158 GeV/c. The resulting plot shown in Fig. 4 is represented by the smooth bold curve. The points on the graph are experimental points for $\theta \sim 90^o$. It is seen from this plot that the point marked c.p. in Figs. 4 and 5 obtained by the Cocconi group at $\theta = 82.4^o$ ($p_{cm}^2 = 14.1$ (GeV/c)^2, $p_{LS} = 30.9$ (GeV/c) and which has been much discussed in connection with the straight line plots shows a much smaller deviation from the bold curve than from the second straight line of Fig. 6. The deviation from this straight line is seen much clearer from Fig. 5 where we have tried to draw two straight lines through the experimental points. It is interesting to note that the slopes of these lines (3.03, 1.40) and their point of intersection ($p_{cm}^2 = 3.3$ (GeV/c)^2) are very close to those of Fig. 6 given by the Akerlof group.

From our plot Fig. 4 there is no doubt that for $\theta \sim 90^{o}$ the experimental points are better fitted by the smooth curve than by an indeterminate number of straight lines. From our survey of the experimental data we arrive at the following conclusions

a) For $\theta \neq 90^{o}$ and for small centre of mass momentum the Orear fit is just not suitable and the Hagedorn theory is being unduly overstretched if it is expected to give results agreeing with experiment in this angular and momentum range.

b) For $\theta \sim 90^{o}$ and for large momentum transfers the phase space statistical theory of Hagedorn can still be trusted.

c) If one is not all out to see them, there are no kinks in the plot of $d\sigma/dt$ against S sinθ, and the imaginary ones already found should by discarged as unphysical.

d) In order to interprete large angle p-p scattering data by means of a more realistic theory than the rather simple-minded statistical one, more experimental points are needed for large centre of mass momenta.

ACKNOWLEDGMENT. -

We are grateful to Prof. Touschek for his interest in this survey and the many suggestions he made for its improvement.

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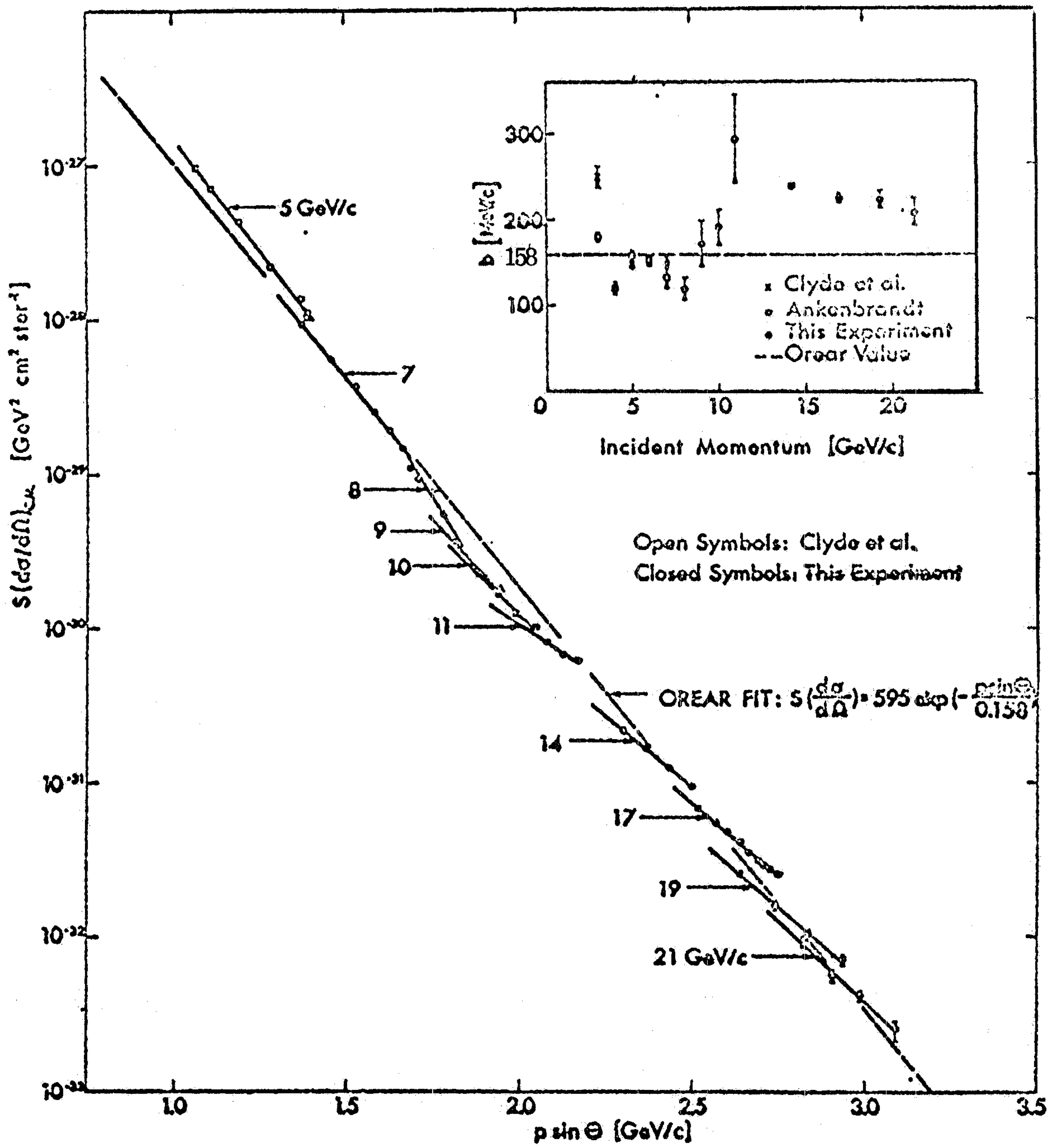
J. V. Allaby et al. , CERN Internal Report (June 1967)



FI G. 1

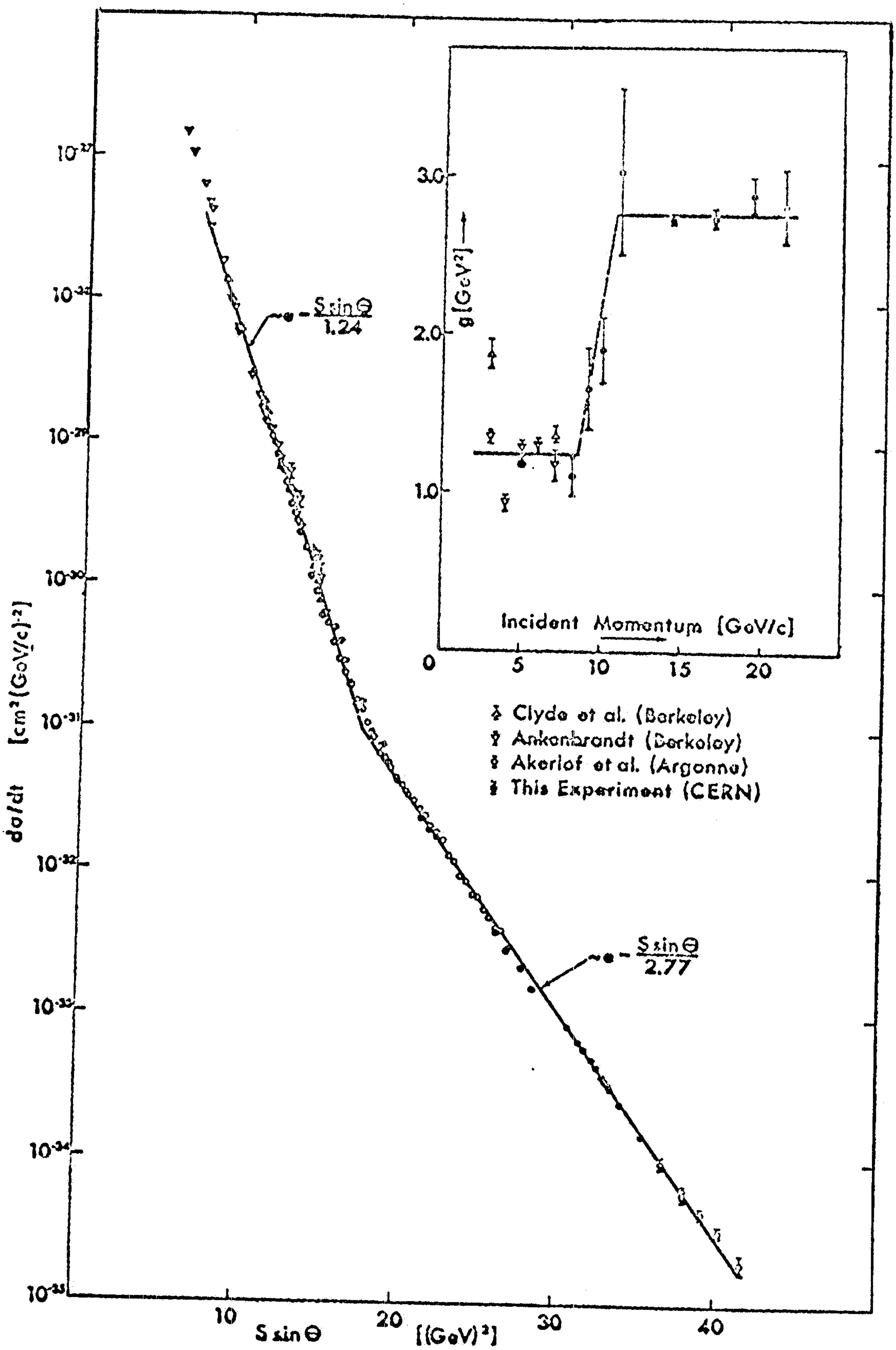

dσ/dt [cm² (GeV/c)⁻²]
S sin Θ [(GeV)²]
10
20
30
40
~e - S sin Θ / 1.24
~e - S sin Θ / 2.77
g [GeV²]
3.0
2.0
1.0
Incident Momentum [GeV/c]
0
5
10
15
20
Clyde et al. (Berkeley)
Ankenbrandt (Berkeley)
Akerlof et al. (Argonne)
This Experiment (CERN)

FIG. 2

C. W. Akerlof et al. , 13th Int. Conf. on High Energy Physics, Berkeley (1966); (cf. Phys. Rev. Letters 17, 1105 (1966))

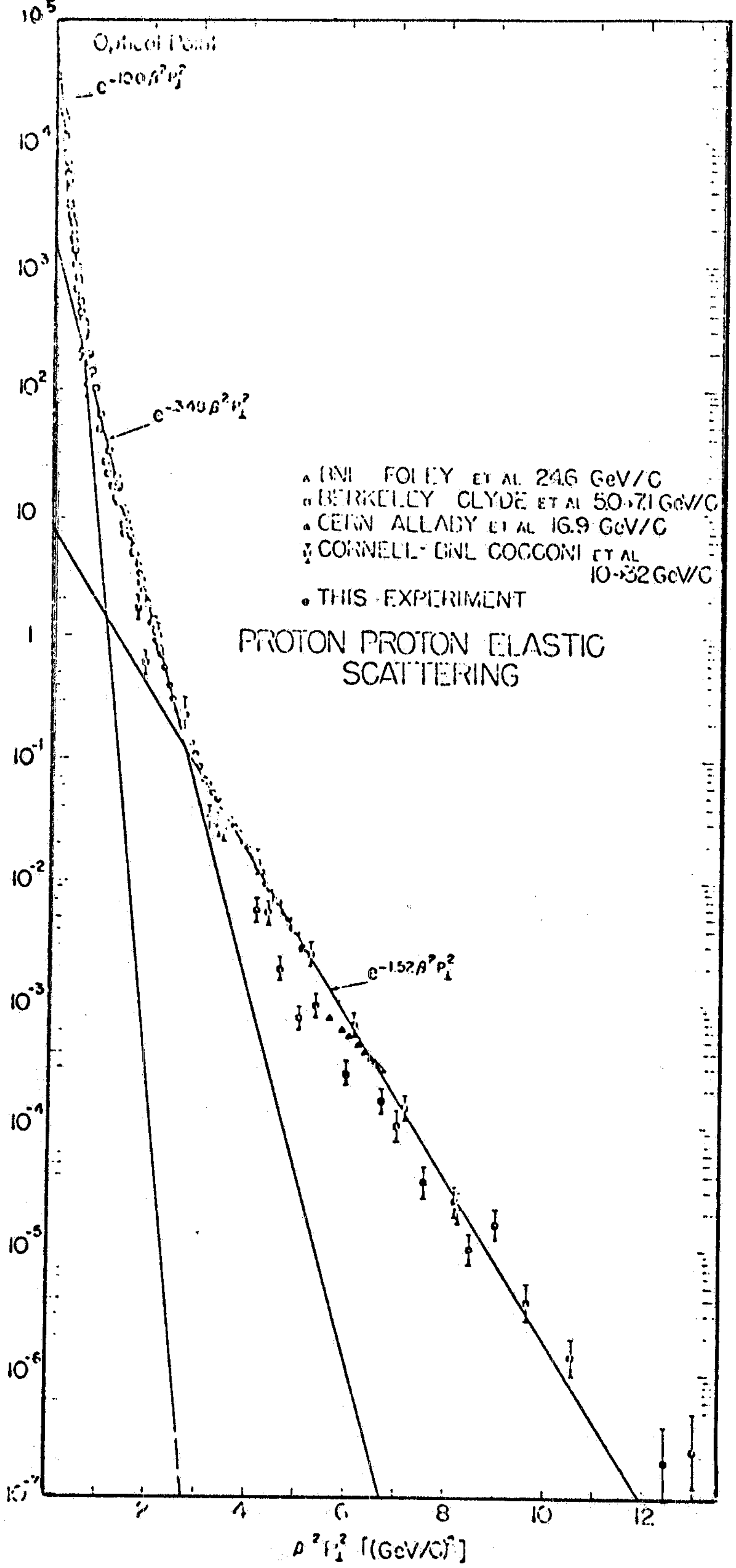


FIG. 3

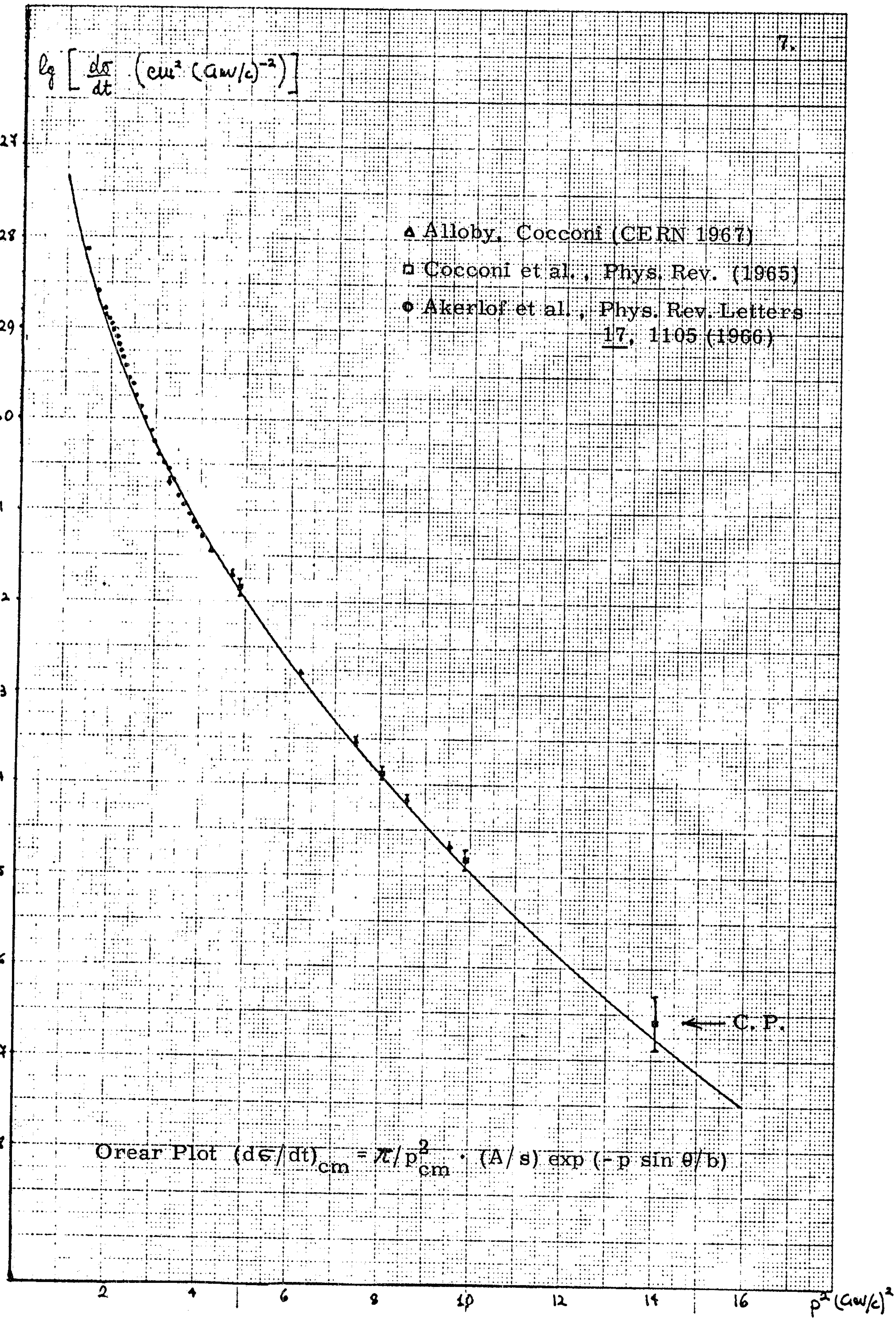
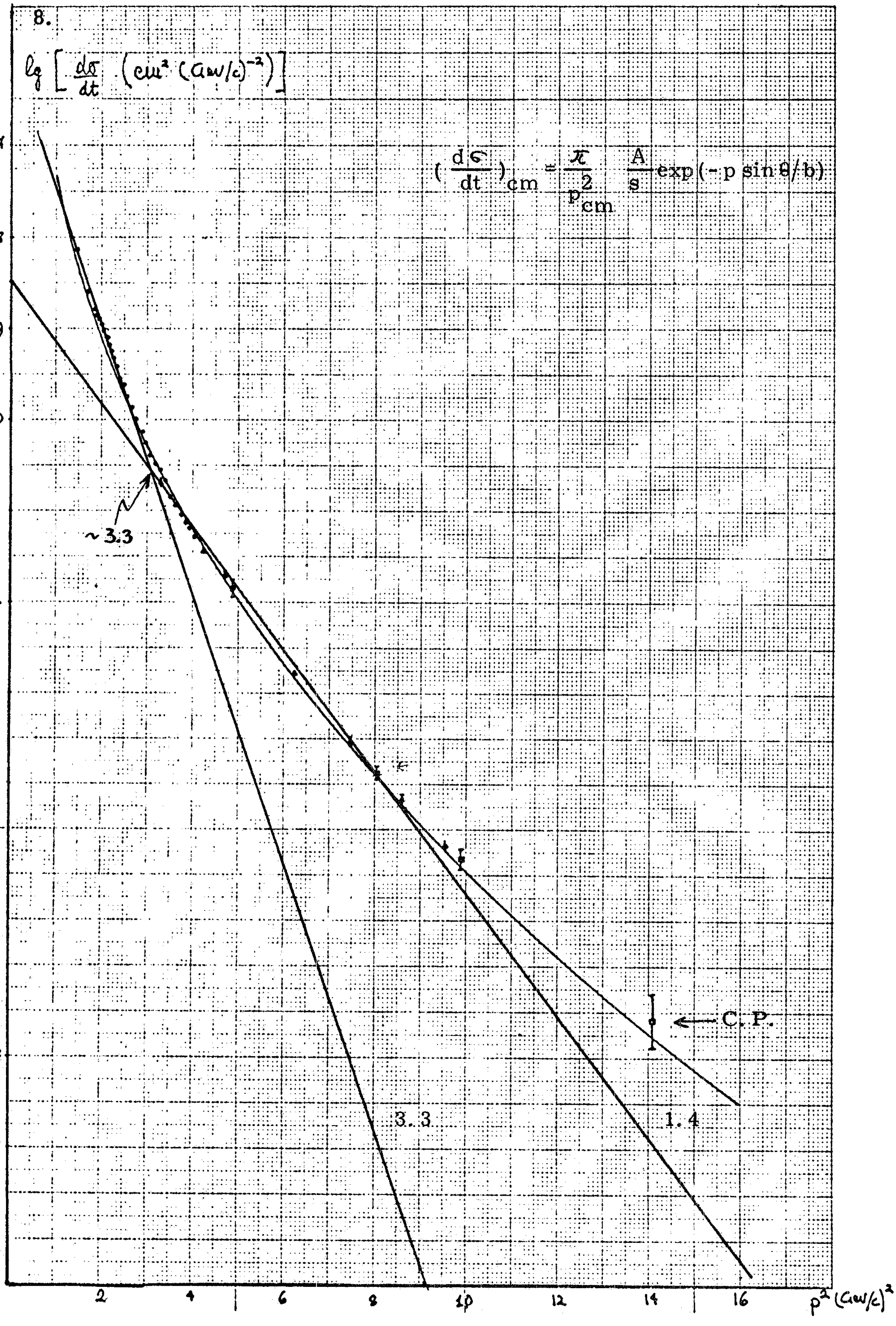

lg [dσ/dt (cm² (GeV/c)⁻²)]
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
2
4
6
8
10
12
14
16
p² (GeV/c)²
Alloby, Cocconi (CERN 1967)
Cocconi et al., Phys. Rev. (1965)
Akerlof et al., Phys. Rev. Letters 17, 1105 (1966)
C. P.
Orear Plot (dσ/dt)cm = π/p²cm · (A/s) exp (-p sin θ/b)

FIG. 4



8.
lg [dσ/dt (cm² (GeV/c)⁻²)]
(dσ/dt)cm = π/p²cm A/s exp(−p sin θ/b)
-27
-28
-29
-30
-31
-32
-33
-34
-35
-36
-37
-38
~3.3
C.P.
3.3
1.4
2
4
6
8
10
12
14
16
p² (GeV/c)²

FIG. 5

C. W. Akerlof et al., 13th Int. Conf. on High Energy Physics, Berkeley (1966); (cf. Phys. Rev. Letters 17, 1105 (1966))

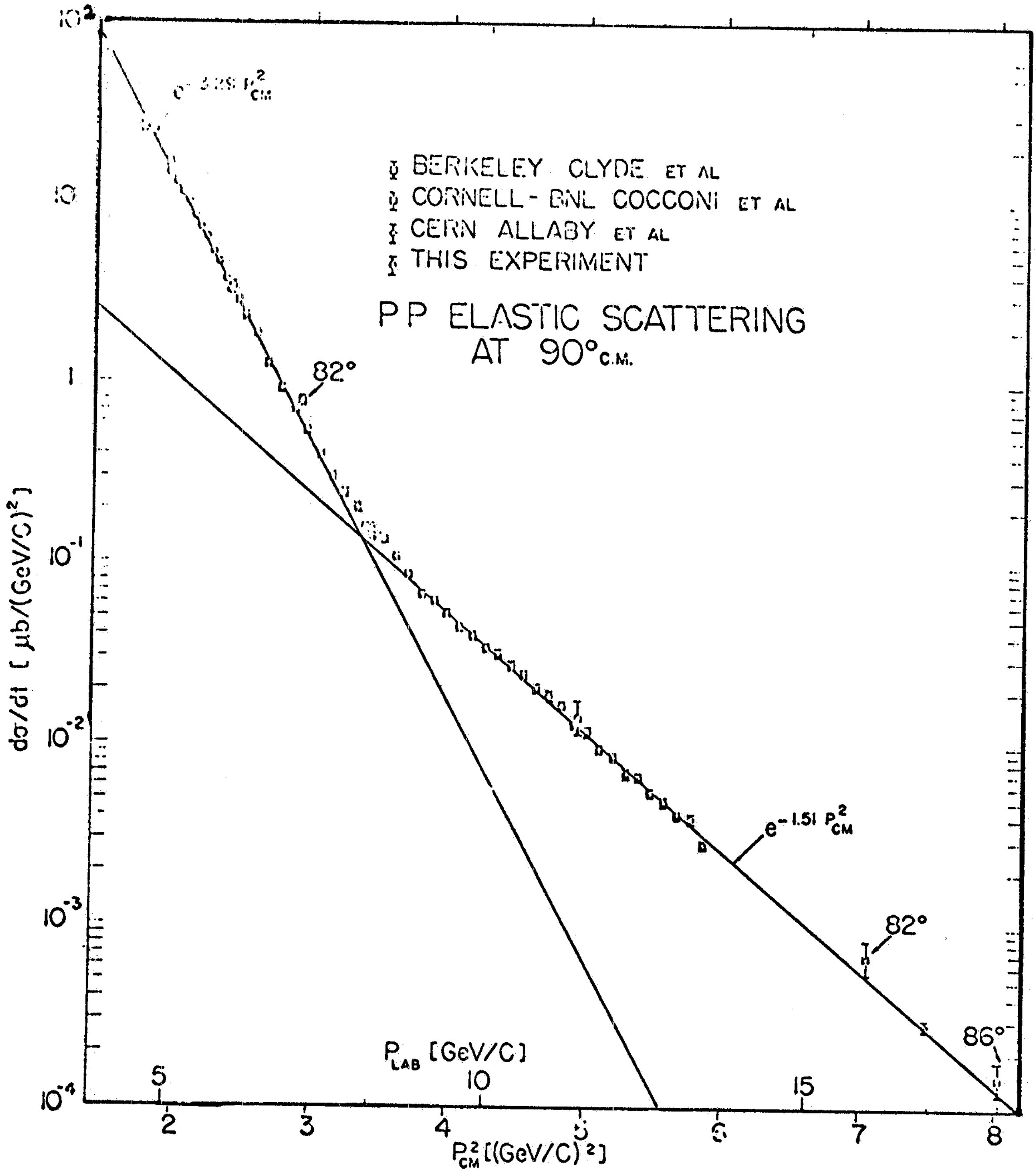


FIG. 6